DOCUMENT RESUME

ED 132 779 EC 092 211

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TITLE Developing and Evaluating Learning Devices for Exceptional Children.
INSTITUTION Tompkins-Seneca-Tioga Board of Cooperative Educational Services, Ithaca, N.Y.
SPONS AGENCY J.M. McDonald Foundation, Inc. Cortland, N.Y.
NOTE 23p.; Best Available Copy

EDRS PRICE MF-$0.83 HC-$1.67 Plus Postage.
DESCRIPTORS Elementary Education; *Equipment Evaluation; Exceptional Child Research; *Handicapped Children; *Instructional Materials; Learning Processes; *Material Development; Mentally Handicapped; Skill Development; *Toys; *Trainable Mentally Handicapped

ABSTRACT

A research project was conducted to develop and evaluate learning products that will assist exceptional children in learning specific skills. To investigate the learning processes of exceptional children, data was gathered from site visits, interviews, observations, relevant literature, copies of curriculum and evaluation forms for exceptional children, and inquiries to 43 toy and educational equipment manufacturers. Differences in learning processes between normal and exceptional children were examined, and various skill development areas were outlined. A list of desired product attributes (such as simplicity and ease of manipulation) were drawn up as an initial step in product development. Five of the learning devices developed (the visual discrimination puzzle, perceptual development cards, body parts puzzle, number puzzle, and measuring device) were tested with 17 children (5 1/2-13 years old) attending primary and intermediate classes for the trainable mentally retarded. Results indicated that use of each of the learning devices increases Ss ability to perform on these devices as well as to apply the skills and concepts to similar, more practical situations. In addition, performance improvement was maintained over time without further contact with four of the five devices (some forgetting over time did occur with the measuring device). (SBH)

DEVELOPING AND EVALUATING LEARNING DEVICES FOR EXCEPTIONAL CHILDREN

Robert Bartholomew   Bonnie Meyer

Introduction. A learning device can be a significant part of the MR child's educational environment, and in the correction of behavioral irregularities. Unfortunately, little has been done, particularly by toy manufacturers, to rigorously evaluate the effectiveness of learning devices or toys with children. Learning devices do not prevent the causes of mental retardation, but they can be useful in aiding the children in acquiring desired skills or in dealing with the learning disabilities. However, the toy industry has not yet shown a great interest in developing learning products for exceptional children despite the considerable need for such devices. In the meantime, some special education institutions and parents make their own toys due to lack of suitable commercially available products. It is recognized that a well-designed learning device may be able to augment classroom activities and permit simultaneous treatment of more than one child at a time. Part of the lack of appropriate toys is apparently due to the size of the handicapped population, which has been regarded as being too small for consideration by the manufacturers. However, it has been one of the hypotheses of this study that toys or learning devices that would also serve the normal child of a similar mental age. Possibly even better than toys, these devices would have a specific goal in instruction as well as entertainment which would be a benefit to both child groups. One of the possibilities may be individualized instruction providing more options in the classroom, in turn requiring more specialized skills for teachers, more diversified curriculum materials and teaching aids than are available in most traditional educational programs.

To explore this issue a research project was conducted, with funding support from the McDonald Foundation. The Fisher-Price Corporation supplied design consultation and the Board of Central Educational Service (Ithaca, N.Y.) provided the test site. Because the goals include determination of the exceptional child's learning processes, skill needs, product development as well as product assessment, a interdisciplinary group was formed to implement the research project.

Objectives. The project objectives are: .

Helping exceptional children gain maximum functional potential in order to enter society or at least achieve a level of performance that will reduce required institutional care.

Augment the normalization process of the exceptional child.

Develop products that will assist exceptional children in learning specific skills.

Organize an evaluation methodology for testing the learning product effectiveness.

Data Collection. Before a decision as to the appropriate product could be made, adequate information concerning the problem parameters was required. Various data collection methods were employed to gather this information including site visits, interviews, and observations.

The inquiry included a literature search of relevant publications for anthropometric data, dealing with physiological measurements, and other physical development information. Little information was found, or according to our sources, little has been done. This is not surprising since the specific disabilities and varying rates of development of the exceptional child make any kind of reliable average information unlikely.

Such information would be very useful to a designer in deciding upon the proper size of given toy parts, size of limbs of a child, perceptual problems, gross or fine motor limitations. However, the exceptional children do share a number of generally recognized difficulties including slow development in motor control and difficulty in grasping which have been pointed out by physical and occupational therapists and special education instructors. However, because of the difference in children, little of a precise nature has been found for guidance.

Copies of curriculum and evaluations form for exceptional children were collected to gain specific knowledge of the functioning level expectations of the various schools concerning the performance of the child. Forty-three toy and educational equipment manufacturers in the U.S. and Europe were contacted to inquire as to the suitability of their product for the handicapped and any works or research in this area they were conducting.

Mental Retardation

It is estimated that there are over six million people in the United States (3% of the population) who should be identified as mentally retarded before they are fifteen years old. At least two million of these children are mildly retarded and many of them may not be singled out and identified until they have been in school for several years. Educators, familiar with the limits of this range generally agree that a child should not be straight-jacketed by categories such as "discipline problem", "slow learner", or "physically impaired", but should be seen as individuals and allowed to develop accordingly.

In studying the learning processes of exceptional children and how they differ from normal children of the same age in intelligence level, it was obvious that we had to take into account certain factors: this included their response to repetition and the use of rewards or positive reinforcement in learning skills. The use of play activities was also recognized a crucial part of the learning process for the handicapped child. We regarded intellectual functioning as a product of the interaction between the individual and his environment and that it can be assisted in its evolution, if the right experience is provided at the appropriate time.

Learning, and the reward, particularly with exceptional children, should be as concrete as possible. This gradual shaping of an individual's behavior toward a particular goal can be done by first assigning specific tasks well within his capabilities and then slowly and sytematically increasing task complexity and moving towards the desired goal. This might mean the use of systematic, sequential methods of instruction to lead a child to gradually bridge the gap from concrete manipulation to abstract manipulation. It is important for learning activities to be self-rewarding so that a child participates because of the enjoyment received. This usually means that the teachers must take the initiative to structure the situation for the child so that success experiences can be guaranteed. This structured teaching situation, into which the devices must fit, means strong involvement by the teacher with the child. Use of operant conditioning or reinforcement of good behavior at the expense of bad behavior, is one of the contributions of a learning device or rather the arrangement of consequences for specified behavior that leads to an increase in the frequency of that behavior. Operant conditioning involves the use of consequences to strengthen or weaken certain behaviors under specific stimulus condition. Different reinforcement techniques can be used (praising, verbal urging) using these techniques facilitates the effects upon psychomotor performance. Reinforcement, tangible or intangible, can be used to motivate performance. Special educators develop their programs in terms of what is needed by the individual to relate to society. Normalization is another way of conceiving of the progress by which the exceptional child is helped to obtain an existance as close to normal as possible.

Behavioral Objectives. As stated previous, the project objectives were primarily to help exceptional children gain maximum functional potential, that is, to enter society or at least achieve a level of performance that will reduce institutional care as much as possible. This includes preparing the individual to help himself to live a happier and more productive life, to do things for himself, and to experience a sense of accomplishment. Often these behavioral objectives have been achieved in programs using behavioral modification, success-oriented play or failure-reduced developmental process. Various skill development areas were recognized as being important or of particular difficulty to exceptional children including:

A. Motor Skills
B. Perception of Spatial Relationships
C. Figure-Ground Discrimination (visual and auditory)
D. Part to Whole Relationship
E. Constancy
F. Body Awareness
G. Math and Science
H. Visual-Motor Skills
I. Tactile Discrimination
J. Attention Span
K. Economic Usefulness
L. Self-Help Skills
M. Perception of Sequence
N. Cognitive Memory Operations
O. Self-Concept
P. Visual Motor Coordination
Q. Association and Generalization

Number concepts, fine and gross motor skills, body-part identification, concept of empty-full and eye-hand coordination, figure-ground studies involving increasingly complex environment. This decision was based on the children's priority requirements, teacher preference, BOCES curriculum, ease of evaluation and the universal use of the selected specific skills.

Product Development. The first steps in the product development procedure was the creation of performance criteria or standards distilled from the collected data. They were to form the guide or requirements for the designers, outlining the defined needs, becoming the framework both for developing alternative solutions, as well as providing general criteria that might be of value to other designers developing products for exceptional children. These criteria were assessed by the members of the project group along with the BOCES staff to arrive at a final draft of the program. In design, the formation of the needed information and project objectives is referred to as "program". This material also formed an evaluation checklist for assessing the relative value of the submitted designs, as well as the rough and final models. An important part of the performance criteria is the inclusion of behavioral objectives or learning goals which the learning devices would aid the child in reaching. It is recognized that particularly with young children the teacher-child interaction may be the most crucial consideration. However, the devices have to supplement or help carry-out the specific behavioral objectives or the curriculum of the teacher or the school. This means that a close dovetailing must exist between these requirements and the support that the learning device has to provide.

A listing of the desired attributes, qualities, or characteristics the end result should possess is listed below, not as a prescription in terms of hardware yet, but rather a description of what the mission of the products should be. It offered a tool for checking with, and agreement among, the project group members before proceeding. Understandably, there are economic manufacturing and marketing considerations that were not part of the design and evaluation problem; hence, the program becomes more optimized and idealistic than might be encountered in a mass-production situation. However, the primary goal of this project was to develop devices that might aid in skill instruction, and if this was successful, the prototypes and concepts could then be translated into a variety of suitable materials. Current material shortages make the specific selection of a manufacturing process or material at this stage unreliable. However, the information contained in this program does provide guidelines or a framework for those interested in developing and/or manufacturing learning devices for handicapped children, understanding that compromises and accomodations to manufacturing and marketing demand will be needed. The general performance criteria are listed below. The various behavioral objectives identified as being appropriate for this project were also considered in the criteria of the program.

Desired Product Attributes

-- Eliminate unnecessary stimuli (break up into a series of smaller response units where possible).

-Simplicity, ease of manipulation. Easy for parents and teachers to use as well. Progressive possibilities--to become more complex or to provide more inputs as needed.

-Ease of replacing parts, non-complicated mechanically, parts that do not become easily lost, or swallowed.

-Scale suited to user, assists in building confidence.

-Durable parts that do not break or shatter, adding to safety and frustration problems.

-Sturdily built of good quality material, able to take abuse.

-Use large elements-ease of picking up and using, including sufficient depth in a hole to hold a part.

-Elements not too heavy to pick up and maneuver, mobility.

-May require more than one person to perform or operate. (Group or social play advantages).

-Low frustration level.

-Gives feedback, does not reinforce mistakes, immediate reinforcement or reward in gratification.

-Based on concrete, real life experiences. Can be adapted to the physically handicapped.

-Avoid ambiguity

-Ease of storage (self-contained) display, security or stealing problem.

-Avoid too many colors. Avoid over-stimulation.

-Should be attractive (have stimulus cues).

-Encourage participation by child or group.

-Provide entertainment, or play value, to encourage use.

-Avoid sharp edges, toxic paint, easily swallowed parts, smoothly finished, avoiding splintering and rough edges.

-Easily cleaned or disinfected.

-Will work with minimum touch or pressure.

-Multi-sensory (if one of the child's channels is not working).

-Teach more than one thing; though cannot be too flexible or complicated, should do at least one thing well. Avoid too many varied functions.

-Accurate fitting of parts.

-Reinforce desired behavior and eliminate undesirable activity.

-Relate to curriculum as prop or aid.

-Permits working from the familiar to the unfamiliar, yet providing a challenge.

-Make the stimulus clear and definite by (a) heightening the value of the desired cues and/or (b) reducing the value of conflicting cues.

-Concepts should be presented in a spiral fashion, deepening and broadening each as it is met at successive levels.

-The more immediate the knowledge of results, the more effective the reinforcement.

-Easy to operate, non-complicated, permit "self-instruction" for learner.

This list is not intended to be exhaustive and it does not offer a priority assignment since this changes from one design situation to another. The designer will have to establish a hierarchy of importance for each of the factors considered in the product design. The project group met at frequent intervals to discuss the performance criteria and the responding concepts. The final prototypes were executed in materials which would provide the durability and cleanability requirements plus providing a faithful rendition of the desired final form. Pre-testing of the learning devices were conducted at Ithaca area exceptional children summer camp with five children who were of similar MA and CA to anticipated subjects. The devices were evaluated for their difficulty level in an attempt to ensure that the devices were neither too easy nor too difficult. The devices tested included the visual discrimination device, number puzzle, figure discrimination device. In addition to eliminating the use of the visual discrimination device, the results of the pre-test provided information for modifying the other devices. These modification included the use of solid rather than hollow (prone to breakage) components, the elimination of sharp edges, and the sealing of the beads in the bottles of the measuring device.

As indicated by our interviews and literature review, there is considerable teacher dissatisfaction with current toys and the suitability of many storebought toys for use by the handicapped child. The toys can become both a medium for learning as well as play. There is also the importance of not only maintaining the child's interest and attracting his attention, but as a means of mastering anxiety, self-realization and expression, and as a curriculum tool that can provide sensory stimulation and cognitive input. Additionally, they can provide ego support, facilitate childrens playfulness, and the simulating of roles. In addition, play is recognized as an effective and natural way of learning for children. Even in the pilot project, the word "toy" was avoided as a descriptive term for the products. This is more than just semantic distinction, but a reflection of the research group's philosophy that a toy's primary intention has been entertainment and not instruction. However, some toys are often used as a means of instruction in learning environments and some manufacturers do make toys for which they claim skill development though these claims should be viewed carefully. While the toy must have a large margin of error and therefore be "open-ended" in its "forgiveness of mistakes", the possibilities with the toy should not be so broad to make it ambiguous to the child when he has achieved success.

A problem area in product development, including the toy field, has been the adequacy of the product evaluation before consumer use. One of the major objectives in this study was to assess the merit of the learning device, in meeting the defined goals. Ideally, the design process would be an evolutionary process where the feed-back from consumer use would provide the designer information for needed product changes. Before public product introduction the "rough" models and pre-test period provided some of this input on this project, but a follow-up phase on this project might include any needed product revisions to the prototypes particularly before mass-production.

Little human factors information was found to be available and what little there is, is not necessarily suitable because of the unique nature of the test subject's varying mental and physical limitations (on development motor abilities). The products were then designed to permit "graspable" surfaces, safety in having soft edges, parts large enough that they cannot be swallowed, and the danger of the toy being used by another child as a hammer.

The inability of the child to control body coordination creates frustration and likely inhibits learning. A child faced with a learning task or with a toy must make a variety of decisions including motor control decisions, such as whether to pick it up and with what hand, how to reach, coordination of the eye and hand, and if any additional parts of his body are needed.

In addition, the devices will need to be adaptable to the curriculum of the school where used. Does the toy do what it was meant to do? Is it safe related to the user? Do the parts fit together ? There are safety problems to watch such as sharp edges, easily shattered parts, electrical hazards, flamability, suffocating or strangulation capabilities which have not always been a major concern of toy manufacturers.

The best toys are ones that continuously give the child room to interact with it enlarging imagination and skills. Perhaps, this suggests a "series" toy that provides greater learning power and complexity in sequential, controlled steps. The toys should also be multi-sensory ~~or~~ so that different children may arrive at the same conclusions or learn the same materials by varying channels.

The use of rewards is recommended as reinforcement and enticement to achievement though rewards should be tangible and immediate. Sometimes called "payoff" toys, the specific reward may be a flashing light, noise feedback on performance in terms of color or moving parts.

Description of Learning Devices

Visual Discrimination Puzzle

Objectives

To encourage matching, differentiation, and recognition of shapes, negative-positive space relationships, and to develop small motor skills.

Product Response

Three separate devices similar in form were designed. Each was a series of shape progressions from either circular to square (the orange puzzle), rectangular to elliptical (the green puzzle), or subtle changes in triangular shapes and edges (the red puzzle). The shape changes were reinforced by color appliques to the top surfaces of the shapes. Depressed areas in a surrounding frame provided a matching negative space for the shapes. The devices developed have self correcting projections to prevent the children from putting the shape in the wrong depression and reinforcing an erroneous match. The self-correcting projections are visible from the top surface of the first device to be developed, the red triangular puzzle, but they are not visible from the top surface of the orange and green puzzles. The later developed orange and green puzzles were made of vacuumed formed plastic for durability and ease of cleaning.

The plastic color is off-while to provide a neutral background for the shapes.

Perceptual Development Cards

Objectives

To develop the child's ability to distinguish particular objects in a visually saturated environment and select the object from a competing background. To develop shape, color and object recognition, and to assist him in adjusting to visual stimuli and working with patterns.

Product Response

A series of cards were developed dealing with an object, a block with an A on it. In each card of the series it became more difficult to find the A block due, to changes in position, size and location of the block and the added stimuli of more distractors on each card. The series dealing with the A Block consisted of three identical sets of cards differing only in whether they were done in line, tone or color. The cards provided varying degrees of abstraction and delineation as typically found in the child's every-day experience. The objects and contexts used were familiar to the child.

Another group of cards included a stop sign, traffic light, number "5", fire hydrant, and cake each boldly displayed on separate cards. The child was to find these objects on a picture of store fronts. The objects were reduced in size, and many interesting distractors were found on a detailed drawing of the store front scene. Thus, for both types of perceptual development cards the child had to keep his attention of his object, look for the object in varying positions, sizes, and locations, and discriminate it from a distracting contexts.

Body Parts Puzzle

Objectives

To aid in body part labeling and matching, and the development. The design of the boy was abstract, rather than completely realistic. The limbs and head are flesh-colored, while the other parts (pants, eyes, vest, etc.) are done in realistic, different colors. The puzzle is made of cleanable, durable acrylic. This was done instead of a neutral color to avoid confusion with the flesh color. The device is self-correcting (the legs cannot fit into the place for the arms).

Number Puzzle

Objectives

To increase the child's knowledge of numerical concepts and number recognition, and to develop fine motor control.

Product Response

Numbers 1 through 9 were developed into separate puzzles. Each number can be divided into acrylic plastic pieces representing the number; for example, number puzzle seven has seven pieces. Each number is a different color and it is placed in a neutral, cleanable, durable acrylic, white frame to provide minimal visual distraction. No texture differences are present in order to eliminate unwanted stimulation. Depressed areas are provided for the insertion of the number pieces into the frame; the color of the depressed areas match the color particular number's pieces.

Measuring Device

Objectives

To develop concepts of empty, full, half full, more, less, in, out, through, right, and left. To promote eye-hand coordination and fine and gross motor coordination.

Product Response

The prototype involves the use of two identical containers connected by a tube which permits small beads to visibly run from one container to another in an eclosed raceway. Graduated marks on the containers permit checking for specific quantities of beads. The measuring device has to be held with two hands in order to manipulate the beads from one container to another, facilitating left-right differentiation and encouraging fine and gross motor control. Different colored beads or different size beads could be used in this device to vary its sight and sound entertainment value. The beads used in the measuring device in the present study were all approximately one-sixteenth inch square and yellow, blue and white in color. Manipulating the beads to different levels in the containers was the aspect of the design thought to develop eye-hand coordination. The parts used in the prototype are durable, cleanable plastic.

Product Evaluation

The purpose of the evaluation of the learning devices was to ascertain the effectiveness of each device and to identify problems of the devices and possible improvements. The effectiveness of each device was gauged by scores on a test that was written to tap the skills taught by the device. Some items on a test for a particular learning device examined a child's ability to perform the skills on the learning device, and other items tested whether the child could generalize the skills taught by the learning device to different situations. A time-series design consists of periodic measurements of the performance of an individual (or group) over a period of time and the introduction of an experimental change into this time series of measurements. Time-series designs have been recommended as useful quasi-experimental designs plus being beneficial in assessing the effects of an intervention, such as psychotherapy, on an individual. The evaluation of the learning devices was concerned with the effects of the intervention of instruction with a learning device on a child's performance of skills which the device was designed to teach. Thus, a time-series design was appropriate for the evaluation of the learning devices.

Subjects

It was decided to evaluate the products in their use with both exceptional and normal children. Seventeen children attending classes at the Special Education Building of the Board of Cooperative Educational Services (BOCES) in Ithaca, New York participated in this study. The intellectual levels of these children as guaged by IQ scores on the Stanford-Binet intelligence scale range 25 to 50 points. The etiology of ten of the seventeen children was Down's Syndrome or mongolism, while the other seven children suffered from brain damage caused by disease or unknown factors. Eight of the seventeen children attended the Primary Class for trainable mentally retarded at BOCES; their ages ranged from 5 1/2 to 10 years old. The other nine children attended the intermediate class for trainable mentally retarded children at BOCES, and their ages ranged from 10 to 13 years of age.

In addition, nine children attending the nursery school at Cornell University participated in the experiment. These children ranged in age from 2 3/4 to 3 1/2 years old. The parents of these children were professional people in the community.

Evaluation Procedure

The basic experimental procedure for the evaluation consisted of pretesting, instruction and post testing. This procedure covered a period of 16 weeks.

Four pretesting sessions were conducted with the exceptional children and the nursery school children who participated in the study. The pretests were administered once a week for four weeks. The test for each learning device was given to each child four times during this pretesting period, except for the test for the Body Parts Puzzle. The Body Parts Puzzle was only evaluated with the exceptional children since the size of the puzzle prohibited its transport to and from BOCES and the Cornell University Nursery School.

Scoring

The scoring of the tests was objective due to the nature of the test items. For example, either the child placed a piece in its correct slot in the puzzle or he did not.

Effects of Learning Devices on Performance of Exceptional Children

An examination of the data indicated that there was no interaction among the learning devices; that is, when learning device one precedes rather than follows device two, the effect of learning device two is not changed. Also, a date examination of the graphs shows that mere passage of time without instruction with the learning devices does not increase test performance. Children not receiving instruction on a learning device during the first week of instruction sessions did not improve in their performance on the tests until they received instruction with the device weeks later. Thus, the increased proficiency on the tests used to evaluate the learning devices cannot be attributed to the children's maturation but rather to instruction with the learning devices. In addition, the data from the Body Parts Puzzle indicates that the effects of the devices are independent of the particular teacher using the device. Equivalent improvement in performance on the Body Parts Puzzle was obtained by each of the three teachers giving instruction with the device. The first post-test mean score corresponds to the first test after instruction, while the last post test mean score corresponds to the test administered after Christmas vacation. It is clear from examining the performance level before and after instruction with the devices in the graphs that performance inproved considerably after instruction with each learning device.

The effects of instruction with the learning devices on test performance is statistically significant at the .0005 level of statistical significance for each learning device. Thus, instruction with each of the learning devices greatly increased the ability of the exceptional children to perform the skills which the devices were designed to teach.

The increase in performance on these generalized tasks was statistically significant at least the .05 level of statistical significance for all the learning devices. The instruction with the learning devices not only improved the children's performance on the devices, but also improved their performance on tasks requiring application of these skills to more practical situations, represented by the generalized test items.

Results

In summary, the use of each of the five learning devices with the trainable MR children increased to a statistically significant degree their ability to perform on these devices as well as to apply these skills and concepts to similar, more practical situations. In addition, this improvement in performance was maintained over time and without further contact with the learning devices for the Figure Discrimination Puzzle, the Perceptual Development Cards, the Body

Puzzle and the Number Puzzle. Some forgetting over time did occur for the Measuring Device, but final post test performance was still significantly better than pretest performance.

Completion of the feedback loop is a desirable phase in the Design Process. On the project, an assessment of the strengths and weaknesses of the products following the product testing was done. Briefly and generally this included the need for larger, more manipulative shapes in the puzzles, use of a plastic coating on the cards to permit the use of markers, more "story content" to the pictorial puzzles, collapseable, large parts for ease of storage and hazard reducing. Further any sharp edges and smoother operation of devices that have movement.

Summary

The objectives of this project have been met in:

a. organization of performance criteria for use in development of learning devices.
b. developing specific product solutions to the defined parameters.
c. formulating and utilizing an evaluation methodology.
d. establishing a model for further learning device design and evaluation.

The teacher feedback from the test site has continued to be encouraging regarding the continued contribution the devices are making to the children skill acquisition. It is intended that the performance criteria, evaluation methodology and the other data generated in the project will encourage further product development by toy manufacturers to meet the established need. Clearly, this project indicates that exceptional children in educational, institutional and home environments may benefit from products such as developed as part of this project.